Anuran Diversity and Ecology from Forest Fragments in Cavite Province, Luzon Island, Philippines*

Rubie M. Causaren[1,4], Arvin C. Diesmos[2] and Neil Aldrin D. Mallari[3]

ABSTRACT

The earliest comprehensive work on Cavite Province's anurans started in 1998 in Mount Palay-Palay/Mataas-na-Gulod Protected Landscape. Annual anuran assessments have been done in this protected area since then, but not for the entire province. The anuran assemblages are also experiencing numerous anthropogenic threats that could affect their diversity. The aim of the study was to determine anuran diversity, richness, and abundance in six secondary lowland forest fragments in Cavite and further contribute to existing knowledge on Philippine anurans. Anuran surveys were conducted from February to September 2010 by employing a combination of strip transect sampling, time-constrained searches, visual encounter survey (VES), and acoustic encounter survey (AES). Utilizing EstimateS v.8.2, species diversity was represented by Shannon's Diversity Index (H'), species richness by the non-parametric Jackknife1 and sampling efficiency by MaoTau. Twenty-one (21) microhabitats were identified, and species diversity and richness were highest in riparian forests during both dry and wet seasons. A total of 17 anuran taxa, including five representing new records for Cavite, were recorded. Species diversity (H´) values slightly varied and a comparison of the MaoTau and the Jackknife1 results indicated that ca. 80-100% of the anuran species were detected from the different forest fragments. The anuran assemblage has a high degree of endemism (70.6%) with two yet-to-be described species, *Platymantis* sp. and *Kaloula* sp., also known to occur in Cavite.

KEY WORDS :

AES
amphibians
Habitats
Jackknife
MaoTau
Microhabitats
VES

INTRODUCTION

The Philippine archipelago was previously thought to have a depauperate herpetofauna, but is currently recognized as one of the most important centers of herpetofaunal diversity and endemism in Southeast Asia (Diesmos et al., 2002b). To date 99 (85%) of the 116 Philippine amphibian species are endemic to the country (ACNA, 2015) (excluding the 6 introduced species and the endemicity is at 90%). However, the amphibians and reptiles of Cavite Province's remaining forest fragments remained poorly known. Very few herpetofaunal studies have been conducted in Cavite and previous studies were limited to the area of Mount Palay-Palay/Mataas-na-Gulod Protected Landscape (henceforth "Palay-Palay"). Two relevant studies were unpublished undergraduate theses of Celis et al. (1996) and Paloma and Panganiban (1997); however, the aforementioned works were chiefly taxonomic. Nevertheless, their results showed that *Pulchrana similis* and *Platymantis corrugatus* were the most abundant frog species in the area while S*phenomorphus* spp. were the most abundant lizard species. To date, much of the information on the area's herpetofauna are based on the studies of Causaren and Lagat who conducted extensive studies since 1998. A total of 14 anuran species (Causaren, 2009) and 36 reptile species (23 lizards, 12 snakes, and 1 turtle; Lagat, 2009) are now known from the protected area.

Many of Cavite Province's remaining forest fragments are unmanaged and continue to experience anthropogenic pressures. Disturbances include illegal logging, road and tunnel construction, poaching, overharvesting of resources, slash-and-burn agriculture (*kaingin*), charcoal-making, and massive quarrying (Causaren, 2012; Lagat 2012). The

[1] Graduate Studies Department, College of Science and Computer Studies, DLSU Dasmariñas City Cavite, Philippines;
[2] Herpetology Section, Zoology Division, Philippine National Museum , Rizal Park, Burgos St., Manila, Philippines;
[3] Fauna and Flora International Philippines, No. 8 Foggy Heights Subdivision, San Jose, Tagaytay City, Philippines.
[4] Correspondence: rmcausaren@dlsud.edu.ph

* Article Details
Submitted : 19 October 2015
Accepted : 3 August 2016

anuran assemblages of the different forest fragments are also threatened by chytridiomycosis, a fungal disease in amphibians caused by the chytrid fungus *Batrachochytrium dendrobatidis* (Bd). Chytridiomycosis is regarded as the greatest known disease threat to vertebrate biodiversity and has been documented to cause massive amphibian population declines and extinction worldwide (Wake and Vredenburg, 2008; Skerrat *et al.*, 2007). Mt. Palay-Palay was found to have high prevalence and relatively high infection intensities for Asia (Swei *et al.*, 2011a and b; Diesmos *et al.*, 2009). Very little is known about the distribution and prevalence of *B. dendrobatidis* in Asia although the Philippines (specifically Mt. Palay-Palay) may represent a site of *B. dendrobatidis* epidemic in this region. With all these scenarios, this study aims to provide baseline data on species diversity, distribution, and ecology of anurans from the remaining forest fragments in Cavite and further contribute to the existing knowledge on Philippine anurans.

Materials and Methods

Study sites: Six secondary lowland forest fragments (ca. 1–640 ha) in Cavite Province (Figure 1, Table 1) were chosen as study sites. These fragments are either remnants from commercial logging activities ca. 25–45 years ago or a direct result of land conversions for agriculture or human settlements (Liu et al., 1993; Tumaneng-Diete et al., 2005). The study area is largely in lowland with elevation ranging from 78–648 meters above sea level (masl).

Site 1 (Buhay), which was reportedly covered by as much as 100 ha of forest, is only covered with ca. 5 ha of forest due to illegal logging, slash-and-burn farming (*kaingin*), and most especially charcoal-making. Two forest fragments, sites 2 (Evercrest) and 4 (Kabangaan), are privately-owned

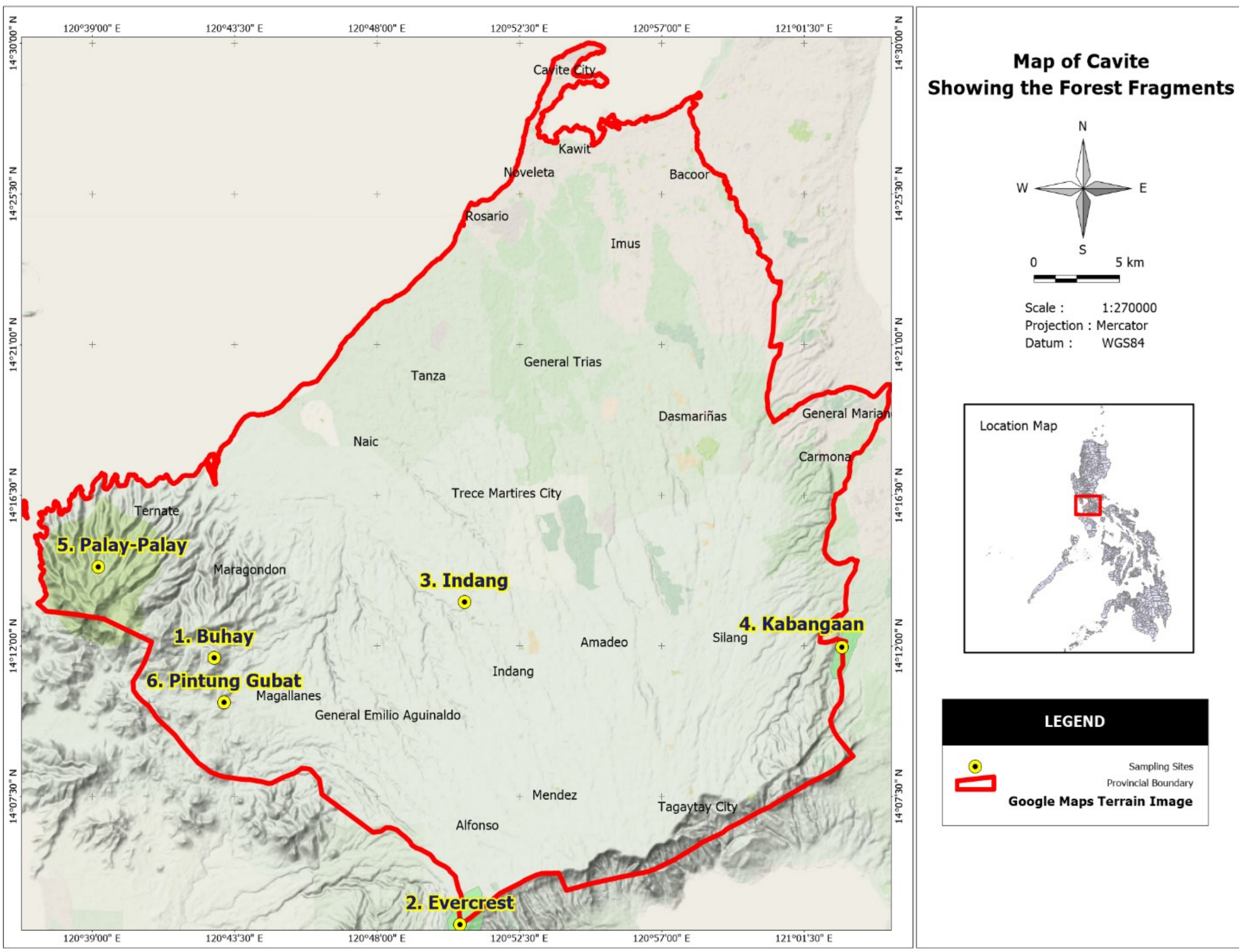

Figure 1: Map of Cavite (outlined in red) showing the forest fragments. Modified from Google Earth 2011.

and are covered with secondary growth forest and experience less disturbance compared with other fragments. Site 3 (Indang) was mainly riparian and the remaining vegetation was located at the very steep slopes of the site. Site 5 (Mt. Palay-Palay) is the only protected area in Cavite (Presidential Proc. No. 1315) and is also subjected to anthropogenic pressures such as illegal logging, poaching, slash-and-burn farming, firewood gathering, harvesting of non-timber forest products, and as pasture areas. Forest cover is only a mere 16% (Environmental Science for Social Change, 2010) from a previously reported 62.5% (DENR, 1992). Site 6 (Pintung Gubat) was previously reported to be covered with 40 ha of forest but only ca. one ha remains, bordering riparian habitats, due to conversion to agricultural lands.

Habitat classification: The habitats were arbitrarily classified in order to determine the number of transects to be sampled per fragment. The classification of habitats was primarily based on how the habitat developed and classification based on tree species composition was only secondary. Based on the context of this study, 'agroforest' was defined as a habitat that was previously subjected to land-use change (*e.g.,* illegal logging, overharvesting, slash-and-burn (*kaingin*)) and other farming activities but became reforested due to incorporation of multifunctional trees into agricultural systems. 'Mixed forest' was defined as a habitat that was also previously subjected to land-use change (*i.e.,* illegal logging) but both natural and artificial regeneration were carried out in the same area, with deliberate silvicultural assistance from man. These were usually the product of tree planting activities done by Department of Environment and Natural Resources (DENR), non-government organizations (NGOs), and corporations. A 'natural forest' was defined as a habitat that originated from an original forest and consisted of natural immigrant tree species and strains that have spontaneously regenerated without interference from man. A 'riparian forest' was defined as a habitat with trees and shrubs located adjacent to streams/rivers/creeks. A 'grassland' was defined as a habitat where the vegetation was dominated by grasses and other herbaceous or non-woody plants. Grasslands were usually parts of the forest edges of the fragments.

Number and distribution of transects: Forty-two (42) standardized 100 x 10 m strip transects (Table 1) were sampled during the dry season and another set of 42 transects were sampled during the wet season, giving a total of 84 transects (representing 0.63 – 40% of the areas of fragment). Research design followed stratified random sampling (Diesmos, 2008) in which strip transects were randomly placed (at least 100 m apart depending on the size of the fragment) in all representative habitats in each forest fragment site. For example, for site 5, 40 strip transects were placed in 5 different habitats. Up to 2 strip transects were sampled each night throughout the study and sampling began immediately after sunset. Night-time sampling was done primarily because anurans are nocturnal or active at night.

Field methods: Field work was conducted from February to September 2010 using various standard methods such as strip transect sampling, time-constrained searches, visual encounter survey (VES), and acoustic encounter survey (AES) (adapted and modified from Crump and Scott, 1994; Heyer et al., 1994; Alcala et al., 2004; Diesmos, 2008). Visual encounter surveys were conducted by walking through a 100 X 10 m transect (transect sampling) for a prescribed time of two hours (time-constrained searches), visually searching for anurans. The transect line was marked at 10-m intervals with numbered fluorescent flagging tapes labeled according to the transect number and point. For each transect, two hours were spent by the same four persons to sample all accessible microhabitats confined within. Microhabitats are specific areas within a community or habitat occupied by certain organisms because of microdifferences in moisture, light, and other conditions like availability of nutrients, protection from predator, and possibility of mating. Examples of microhabitats were forest floor litter, tree holes, rock crevices, spaces between buttresses of trees, forest shrubs, and axils of palms, epiphytes, tree ferns, and aerial ferns. Prior to sampling, the first two points (points 0 and 1; with a distance of 10 m) were marked and 12 minutes were spent in sampling this particular portion of the transect, after which all anuran individuals whether seen, heard, or caught were recorded. This was done repeatedly until all the succeeding portions of the transect were sampled. Point sampling was done to minimize disturbance within the transect. The sampling effort was 168 hours/person.

VES was supplemented with acoustic encounter survey where anuran species were identified by their calls (aural identification). Male advertisement calls have been used as a taxonomic character in the identification of frogs (see, e.g., Brown and Alcala, 1986; Brown et al., 1997a; Alcala and Brown, 1998). The number of anurans encountered (by both visual and aural methods) was recorded.

All captured frogs were processed and identified to species level, measured, classified according to sex and age, and released at/near sites of capture. Nomenclature of anurans followed Alcala (1986), Brown et al. (1996), Brown et al. (1997a, b, c), Alcala and Brown (1998), Diesmos (1998, 1999, 2008), and Frost (2010). Voucher specimens of possible undescribed taxa and those that could not be confidently identified in the field were collected and preserved using standard preservation techniques and storage (Pisani, 1973; Heyer et al., 1994). Prior to specimen preservation, liver tissue samples were preserved in 95% ethanol in tissue tubes for future studies. Voucher specimens and liver tissue samples were deposited in the Herpetology section of the Philippine National Museum, Manila City.

Table 1. Description of the study sites with biogeographic and ecological variables.*

Sites	Forest fragment	Locality	Coordinates	Elev. (masl)	Habitats available	No. of transects sampled		Total no. of transects sampled	Total area sampled (in ha)	Forest cover (in ha)	% sampled area relative to locality area
						Dry	Wet				
1	Buhay	Brgy. San Agustin, Magallanes	14°11'39.1" N 120°42'51.1" E	284	open/grassland	2	2				
					mixed forest	2	2				
					riparian forest	2	2				
					natural forest	2	2	16	1.60	5	32%
2	Evercrest	Brgy. Amuyong, Alfonso	14°03'41.0" N 120°50'37.0" E	550	natural forest	4	4	8	0.80	4	20%
3	Indang	Brgy. Banaba Cerca, Indang	14°13'19.2" N 120°50'45.5" E	125	riparian forest	2	2	4	0.40	1	40%
4	Kabangaan	Brgy. Kabangaan, Silang	14°11'57.8" N 121°02'41.5" E	378	agroforest	2	2				
					riparian forest	2	2				
					natural forest	2	2	12	1.20	10	12%
5	Palay-Palay	Maragondon & Ternate	14°14'22.0" N 120°39'11.2" E	648	open/grassland	4	4				
					agroforest	4	4				
					mixed forest	4	4				
					riparian forest	4	4				
					natural forest	4	4	40	4.00	640	0.63%
6	Pintung Gubat	Brgy. Urdaneta, Magallanes	14°10'19.0" N 120°43'09.8" E	78	riparian forest	2	2	4	0.40	1	40%
Total number of transects						42	42	84			

**Data for forest cover are estimates.*

Data Analysis: The Shannon–Wiener index (H′; Shannon, 1948) was used to represent anuran species diversity (Dixo and Martins, 2008; Diesmos, 2008; Magurran, 2004). Species richness is the most commonly used biodiversity indicator in conservation and ecological research (Gaston, 1996). Species richness of each forest fragment was determined by using the estimator Jackknife1 (Jack1; Stigler, 1977) which is considered to be a robust estimator of species richness (Mallari, 2009; Hortal *et al.*, 2006; Veith *et al.*, 2004). In order to describe the relationship between sampling effort and sampling success, rarefaction (species accumulation curve *i.e.,* Mao Tau) analysis (Gotelli and Colwell, 2001) was employed (Mallari, 2009; Diesmos, 2008; Loehle *et al.*, 2005). This was done to determine the number of species that were overlooked due to incomplete detection. Rarefaction estimates the number of species from a given sample of point transects based on multiple random sampling and would show if the fragments have been sampled representatively. Species richness estimates and accumulation curves (sample-based rarefaction curves) were calculated (500 randomizations without replacement) using the EstimateS v.8.2 (Colwell, 2009). Data from non-random searches/overall collection were only considered to note overall species diversity but were not used in the computation of species richness and abundance. Faunal similarity among the fragments and among mountains of southern Luzon was computed using the Sørensen's similarity index (S; Sørensen, 1948). Species abundance was computed by getting the quotient of number of individuals of a species and total number of individuals multiplied by 100.

RESULTS

Species Diversity and Endemism: A total of 2499 individuals representing four families, eight genera, and 17 species was recorded from the forest fragments and matrix habitat (Table 2). Five species (*Kaloula conjuncta conjuncta, Platymantis luzonensis,* and *Sanguirana luzonensis*) are new records from Cavite Province including two undescribed species currently known only to occur in Cavite (*Platymantis* sp. and *Kaloula* sp.) (Figure 2). The anuran assemblage in the study area has a high degree of endemism. Twelve (70.6%) of the 17 species are endemic to the Philippines and of these endemics, eight (67%) species are confined only to Luzon biogeographic region. Five species are included in the global list of near threatened fauna (Table 2, IUCN 2010), most of which inhabit riparian forests.

A comparison of the expected number of species observed (Mao Tau) to the species richness (Jackknife1) indicated that ca. 80-100% of the anuran species were detected from the different forest fragments (Table 3). From among the forest fragments, Mao Tau and Jackknife1 were highest in Kabangaan fragment followed by Palay-Palay and lowest in Evercrest Forest Reserve. Comparing Mao Tau and Jackknife1 values across habitats showed riparian forest areas were richest in terms of species in all fragments with such habitat. This again shows the dependence of anurans on water. Species diversity (H´) values slightly vary among the fragments except Evercrest which had the lowest value of only 0.84.

Similarity of Anuran Communities in Different Fragments: Data indicate that a certain degree of affinity exists among the anuran fauna of these fragments in that they share an endemic species, *P. mimulus*. *P. mimulus* was shown to be more tolerant to habitat disturbances compared to other *Platymantis* spp. (Causaren 2012). Among the forest fragments, Kabangaan is most faunistically similar to Mt. Palay-Palay by sharing 74% of its species and six endemic species (Table 4). In addition among the endemic species, *P. luzonensis* is restricted only to these fragments. Kabangaan fragment also harbors three unique endemic species, *Kaloula* sp., *K. c. conjuncta*, and *S. luzonensis* and represents new records from Cavite Province. Two endemic species, on the other hand, are restricted only to Mt. Palay-Palay: *Platymantis* sp. and *P. similis*. Among the fragments, Buhay, Indang, and Pintung Gubat shared ≥80% of their species and shared three endemic species, *L. macrocephalus*, *L. woodworthi*, and *P. mimulus*. On the other hand, Palay-Palay, Kabangaan, and Buhay shared ≥70% of their species and shared four endemic species. Evercrest forest appeared to be the least faunistically similar to all fragments.

Habitat Distribution: Based on data from five habitats, species diversity (H′) and mean species richness values were highest in riparian habitats while H′ values for the remaining four habitats slightly varied (Table 5). The same trend was observed during the dry and wet seasons with riparian forests having the highest H′ values (Tables 6 and 7). However, species diversity is higher in riparian forests during the wet season. During the wet season also, H′ value in grassland was higher compared to the dry season but species diversities in agroforest, forests, and mixed forests were lower as compared to the dry season. During the dry season, most species (16 species were found in riparian forests. Data suggest that as an adaptation to dry season, terrestrial species migrate towards riparian areas to protect themselves against desiccation.

Microhabitat Distribution: Twenty-one (21) microhabitats were identified and a large proportion (47.6%) of anurans occurred only in 'forest floor litter' (Table 8). Among the inhabitants of forest floor litter, *Platymantis* spp. had the highest occurrence (96.1%) with *P. mimulus* having the highest degree of occurrence of 60% followed by *P.*

Table 2. Summary information on life history and some ecological traits of the anurans from the different forest fragments.

Species	ML	HA	RL
BUFONIDAE			
Rhinella marina+ (Linnaeus, 1758)	1	3,5	1
MICROHYLIDAE			
Kaloula conjuncta conjuncta* (Peters, 1863)	1,4	2	1
Kaloula picta (Duméril and Bibron, 1841)	1	5	1
Kaloula* sp. *	1	1,3,5	-
RANIDAE			
Hylarana erythraea+ (Schlegel, 1837)	2	5	1
Limnonectes macrocephalus* (Inger, 1954)	2	2,3,4,5	2
Limnonectes woodworthi* (Taylor, 1923)	2	1,2,3,4,5	1
Occidozyga laevis (Günther, 1858)	2	1,2,3,4,5	1
Platymantis corrugatus (Duméril, 1853)	1	1,2,4,5	1
Platymantis dorsalis (Duméril, 1853)	1	1,2,4,5	1
Platymantis luzonensis* Brown, Alcala, Diesmos, and Alcala, 1997	3	5	2
Platymantis mimulus* Brown, Alcala, and Diesmos, 1997	1	1,2,3,4,5	2
***Platymantis* sp.**	1	5	-
Pulchrana similis* (Günther, 1873)	2	4,5	2
Sanguirana luzonensis* (Boulenger, 1896)	2,4	5	2
RHACOPHORIDAE			
Polypedates leucomystax (Gravenhorst, 1829)	3	1,2,3,4,5	1
Rhacophorus pardalis (Günther, 1859)	3	1,2,4,5	1

Ecological status (in boldface = Philippine endemic, ** = Luzon endemic, + = introduced); mode of life, *ML* (1 = terrestrial, 2 = aquatic and terrestrial, 3 = arboreal, 4 = semi-arboreal) was based from Alcala and Brown (1998) and Diesmos (1998, 1999, 2008); habitat, *HA* (1 = agroforest, 2 = forest, 3 = grassland, 4 = mixed forest, 5 = riparian forest) was based from this study; and red list category, *RL* (1 = least concern, 2 = near threatened) was based from IUCN (2010).

dorsalis with 30%. All *Platymantis* spp. recorded from the study area are forest floor dwellers except for *P. luzonensis*. Among the *Platymantis* spp., *P. mimulus* also had the widest microhabitat distribution occupying 17 (81%) of the 21 microhabitats. This may be one of the reasons behind the success of this species in adapting to its environment making it also the most abundant among the anuran species.

Four microhabitats are known to have important functions in the life history of amphibians: diurnal shelter, calling site, breeding site, and oviposition site (Diesmos, 1998; Inger and Stuebing, 1997; Crump, 1982; Heatwole, 1982). Diurnal shelters are microhabitats where nocturnal species retreat into during daytime protecting anurans from predation and desiccation. Microhabitats where male frogs call and mate with females (amplexus or 'copulatory embrace') are known as calling and breeding sites while egg-laying and deposition take place in oviposition sites.

Forest floor litter appeared to be the most important diurnal shelter for all species of *Platymantis* except *P. luzonensis.* Majority of the aquatic ranid frogs such as *H. erythraea*, *P. similis*, *L. macrocephalus*, *L. woodworthi* and *O. laevis* hide under rocks in streams. During the wet season, individuals of *O. laevis* and *L. woodworthi* take advantage of temporary puddles in grassland areas. Species of the genus *Kaloula* were found mostly on soil, under the sand, and in forest floor litter. Of the rhacophorids, the diurnal shelter of *P. leucomystax* appeared to be shrubs and bamboos. Most individuals of *R. pardalis* were observed on aroids, on tree stems/trunks and on shrubs.

In relation to calling and breeding sites, most anuran species called in choruses which means that they can coexist in a common habitat. No anuran eggs were observed during the study except those belonging to the arboreal tree frogs that produced their foam nests.

Table 3. Species richness estimates (Jackknife1) and diversity (H′) in each forest fragment based on non-parametric estimators in EstimateS. Shown also are the number of species observed (Mao Tau) in each fragment and the survey effort measured as to the number of transects per fragment.

Forest fragment	Survey effort (number of transects per habitat type)	Individuals observed	Species observed (Mao Tau) ± Standard error	Species richness (Jackknife 1) ± Standard error	Proportion detected	Species diversity (Shannon H' mean)
Buhay	16	216	8 ± 0.00	8.00 ± 0.00	1.00	1.42
Evercrest	8	208	4 ± 0.63	4.88 ± 0.88	0.82	0.84
Indang	4	74	8 ± 0.83	9.50 ± 0.87	0.84	1.69
Kabangaan	12	437	15 ± 1.28	18.67 ± 2.07	0.80	1.70
Palay-Palay	40	1533	11 ± 0.95	12.95 ± 1.36	0.85	1.76
Pintung Gubat	4	31	5 ± 0.43	5.75 ± 0.75	0.87	1.46

Table 4. Faunal similarity indices of the different forest fragments. Number of species common to fragments inside parenthesis (common to both, endemics).

Fragment	Kabangaan	Buhay	Indang	Evercrest	Pintung Gubat
Palay-Palay	0.74 (10, 6)	0.70 (7, 4)	0.60 (6, 3)	0.59 (5, 3)	0.47 (4, 2)
Kabangaan		0.70 (8, 4)	0.61 (7, 3)	0.50 (5, 3)	0.50 (5, 2)
Buhay			0.88 (7, 3)	0.46 (3, 2)	0.80 (5, 2)
Indang				0.31 (2, 1)	0.80 (5, 2)
Evercrest					0.40 (2, 1)

Table 5. Species richness estimates (± SE) and diversity (H') in different habitats (based on non- parametric estimators in EstimateS) pooled for both wet and dry season. Shown also are the number of species observed (Mao Tau) in each habitat type and the survey effort measured as to the number of transects per habitat type.

Habitat	Survey effort (# of transects)	Individuals observed	Species observed (Mao Tau) ± Standard error	Species richness (Jackknife 1) ± Standard error	Proportion detected	Species diversity (Shannon H' mean)
Agroforest	12	252	8 ± 1.23	9.83 ± 1.24	0.83	1.52
Natural Forest	24	602	10 ± 1.74	12.88 ± 1.59	0.85	1.12
Grassland	12	61	6 ± 0.47	6.92 ± 0.92	0.89	1.34
Mixed	12	290	9 ± 0.39	9.92 ± 0.92	0.75	1.66
Riparian	24	1294	16 ± 1.31	17.92 ± 1.33	0.92	2.09

Table 6. Species richness estimates (± SE) and diversity (H') (based on non-parametric estimators in EstimateS) in different habitats during the dry season. Shown also is the number of species observed (Mao Tau) in each habitat type.

Habitat	Survey effort (# of transects)	Individuals observed	Species observed (Mao Tau) ± Standard error	Species richness (Jackknife 1) ± Standard error	Proportion detected	Species diversity (Shannon H' mean)
Agroforest	12	129	7 ± 0.72	8.75 ± 1.05	0.64	1.66
Natural Forest	12	290	8 ± 1.08	10.75 ± 1.44	0.75	1.06
Grassland	12	11	2 ± 0.59	2.83 ± 0.83	0.69	0.66
Mixed	24	108	8 ± 0.29	8.83 ± 0.83	0.84	1.76
Riparian	24	1024	16 ± 1.13	18.75 ± 1.44	0.87	1.99

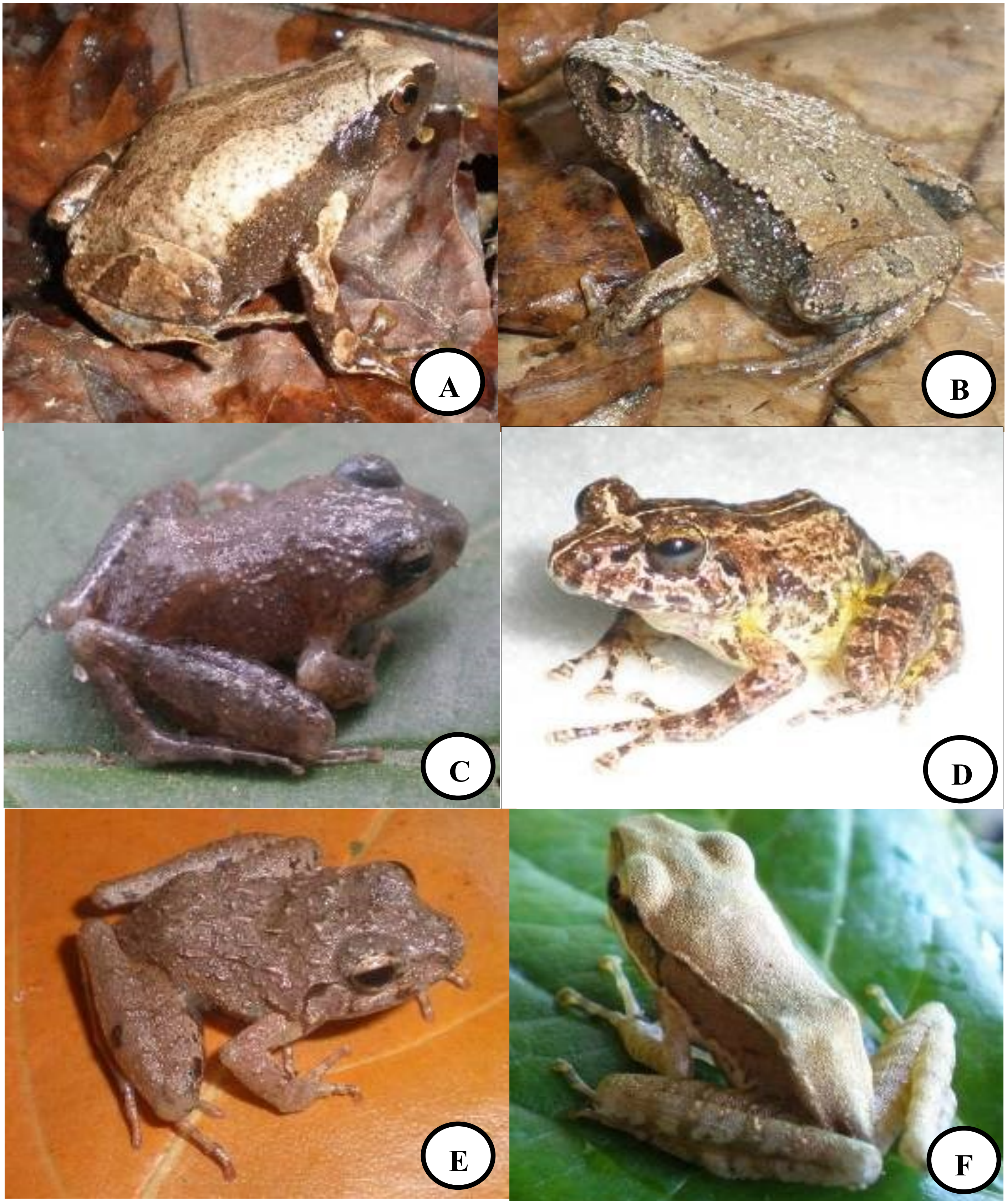

Figure 2. Five species which are new records for the province of Cavite includes A. *Kaloula conjuncta conjuncta*; B. *Kaloula* sp.; C. *Platymantis* sp.; D. *Platymantis luzonensis* ; E. *Platymantis mimulus* shared by all fragments; and F. *Sanguirana luzonensis*. Photos by Rubie Maranan Causaren.

Table 7. Species richness estimates (± SE) and diversity (H') (based on non-parametric estimators in EstimateS) in different habitats during the wet season. Shown also is the number of species observed (Mao Tau) in each habitat type.

Habitat	Survey effort (# of transects)	Individuals observed	Species observed (Mao Tau) ± Standard error	Species richness (Jackknife 1) ± Standard error	Proportion detected	Species diversity (Shannon H' mean)
Agroforest	12	123	6 ± 0.32	6.83 ± 0.83	0.77	0.93
Natural forest	12	312	7 ± 1.21	8.83 ± 1.83	0.84	0.95
Grassland	12	50	6 ± 0.45	6.83 ± 0.83	0.89	1.41
Mixed	24	182	5 ± 0.85	6.67 ± 1.67	0.66	0.83
Riparian	24	270	12 ± 1.14	13.83 ± 1.24	0.88	2.14

Discussion

Data on the anuran species inhabiting the remaining forest fragments of Cavite significantly contribute to the existing data for the Philippines. Two fragments, Mt. Palay-Palay and especially the small fragment of Kabangaan, harbor a number of endemic species. In terms of diversity and endemism, Mt. Palay-Palay is now considered an important area not only for anurans but also for reptiles (Lagat, 2009, 1999) and birds (Mallari *et al.*, 2001). The same case could be true to Kabangaan forest fragment. Available data on anuran richness show that the anuran assemblages of Mt. Palay-Palay (16 species) and Kabangaan (15 species) are comparable to other mountains/areas of Luzon: Babuyan Islands (7 species; Broad and Oliveros, 2004); Zambales (13 species; Brown *et al.*, 1996), Catanduanes (13 species; Ross and Gonzales, 1992), Mindoro (13 species; Alviola *et al.*, 1998, Ticsay and Ledesma, 1998), Palawan (14 species; Alcala and Diesmos, 2008; Baldera *et al.*, 2004; Peneyra, 2004; Brown, 1998), Polilio (20 species; Diesmos *et al.*, 2002a; Hampson, 2001), Maquiling (22 species; Diesmos, 1999, 1998; Alcala and Brown, 1998), Cordillera (23 species, Diesmos *et al.*, 2003), Banahao (25 species; Diesmos, 1999, 1998; Alcala and Brown, 1998), and the Sierra Madres (25 species; Diesmos, 2008; Duya *et al.*, 2004; Brown *et al.*, 2000b).

The remaining forest fragments of Cavite also represent crucial habitats for five Luzon endemic anuran species (*P. similis*, *L. macrocephalus*, *P. luzonensis*, *P. mimulus*, and *S. luzonensis*) listed as near threatened by the IUCN (2010). Among the fragments, *P. similis* was found only in Mt. Palay-Palay and was reported to have relatively high chytridiomycosis infections (Swei *et al.*, 2011 a and b). Mt. Palay-Palay is already on the watch list, as it could be the possible epidemic center for chytridiomycosis in Asia. On the other hand, *S. luzonensis* was found only in Kabangaan forest fragment making it a very important area for conservation. Aside from supporting *P. luzonensis* (which was not found in other fragments), two possible Cavite endemic species are currently known to occur in these two fragments. These were *Platymantis* sp. and *Kaloula* sp. from Mt. Palay-Palay and Kabangaan, respectively. The other fragments also provide important habitats for other near threatened species such as *L. macrocephalus* and *P. mimulus*. Thus, conservation of Cavite's remaining forest fragments is highly warranted as they provide crucial habitats for the survival of our native and endemic anuran species and especially that these fragments are subjected to different anthropogenic pressures (Arsenio *et al.*, 2011; Causaren, 2009; Lagat, 2009; Luyon and Medecilo, 2006; Mallari *et al.*, 2001).

Species richness was highest in riparian areas for both dry and wet season. Results conform with the knowledge that riparian habitats often have high species diversity (Green, 2007; Zaimes, 2007; Pusey and Arthington, 2003; Brigham, 1993; Bunnell and Dupuis, 1993; Guppy, 1993; Poulin, 1993; Weir, 1993) indicating dependence of anurans on water bodies. Number of individuals was also highest in riparian habitats during dry season and in natural forests during the wet season. This may be due to that microclimatic conditions of riparian areas may not suffer drastic variations during the dry season (De Souza and Eterovick, 2010; Dixo and Martins, 2008; Kluber *et al.*, 2008). It clearly shows that riparian areas should be protected and conserved because they are very crucial in maintaining microclimates and provide critical microhabitats for amphibians and other vertebrate taxa as well.

The availability of microhabitats plays vital roles in the life histories, abundance, and distribution of anurans. In this study, anuran distribution is mainly dictated by their mode of life, *i.e.*, ground-dwelling species tend to prefer terrestrial microhabitats while arboreal ones mainly use arboreal microhabitats. Though predominantly terrestrial, *Platymantis* spp. (particularly *P. dorsalis* and *P. mimulus*) and *Kaloula* sp. were observed in arboreal situations where they 'called' their mates. Most anurans also occupied discrete microhabitats and appeared to be 'specialists' to certain microhabitats. This is specifically true for *Kaloula* spp., *P. corrugatus* and *P. luzonensis*. Even if this is the case, different

Table 8. Microhabitat distribution of anurans.

SPECIES	No. of individuals	Microhabitats																					No. of microhabitats occupied per species
						Tree																	
		Aroid	Bamboo	Banana plant	Forest floor litter	Branch	Buttress	Crevice/holes	Stem/Trunk	Driftwood crevice	Fern/fern allies	Log	Puddles	Rattan leaf	Riverbank	Rocks	Sand	Shrubs	Soil	Twigs	Vine	Water bodies	
Hylarana erythraea	33					1	2		1		2				3	10		4		4		6	9
Kaloula conjuncta conjuncta	3															1	1	1					3
Kaloula picta	8				2												3		3				3
Kaloula sp.	12				5									1					6				3
Limnonectes macrocephalus	57				2						1		1			34	2		8			9	7
Limnonectes woodworthi	168				22								8		1	105			2			30	6
Occidozyga laevis	179				8								26		1	15						129	5
Platymantis corrugatus	69				59		4									6							3
Platymantis dorsalis	495	1			347	1	16		3		3	2				54		8	35	10		15	12
Platymantis luzonensis	14					2		10	2														3
Platymantis mimulus	966	2	4		687	4	39	6	4	7	4	3		4		49		35	38	57	1	22	17
Platymantis sp.	1				1																		1
Polypedates leucomystax	109		22	3	1	7		1	2				7			11		45	9	1			11
Pulchrana similis	166	1			1		5				3					138			10	5		3	8
Rhacophorus pardalis	80	24		1	1	10			18							4		20			1	1	9
Rhinella marina	32				2								1		1	4			4			20	6
Sanguirana luzonensis	1	1																					1
Total	2393	29	26	4	1138	25	66	17	30	7	13	5	43	5	6	431	6	113	115	77	2	235	

anuran species were able to co-exist with one another by sharing similar and related microhabitats.

The remaining forest fragments of Cavite, especially Kabangaan and Palay-Palay, are vital for the protection and conservation of many of our native and endemic anuran species. This study also highlights the importance of conserving riparian areas because they are very crucial in maitaining microclimates and microhabitats which play vital roles in the life histories, abundance, and distribution of different anuran species.

Acknowledgements

We wish to thank different institutions and people who provided various help during the course of the study. We are indebted to Edilberto and Elma Perido, Aldrin and Nora Bayla, Estanislao and Muying Paiton, Nano and Elvie Bergado, Joenil and Melinda Nomananap, Teddy Bergado, Jason Fernandez, Danny Tandang, Sales and Philip Cabingan, Nestor Bayla, Ivan and Roxanne Bayla, Roy Alcaraz, Reinel Natividad, Miguelito Baylon, Jo Lester Belardo, Jay-ar Marcaida, Arman and Jay-R Lagat, Omar Mojica, † Mariano Digo, Alvin and Mary-Ann Bergado, Brgy. Capt. Ray Ambat, Mr. Miguel Puyat (thru Mr. Mar Salazar and Mr. Sherwin Abeleda), Harold Asa, Melanie Medecilo, Johnny Ching, Carmela Reyes, Challiz Feranil, Celina Sarmiento, and Alvin Laurio who extended various assistance during the span of this research. Special thanks is given to Ruth Maranan-Asa, Myra Lagat, Ronald Lagat, and Marvin Causaren. We thank DLSU-Manila, DLSU-D, the Protected Area Management Board and staff of Mt. Palay-Palay, and Department of Environment and Natural Resources Region 4 for the technical support during the span of the study.

Literature Cited

Amphibian Conservation Needs Assessment. 2015. A conservation needs assessment workshop for amphibians of the Philippines held at the Fauna and Flora

International Office in Tagaytay City, Cavite, Philippines on June 10-12, 2015.

Alcala, A. C. 1986. Guide to Philippine Flora and Fauna, Vol. X, Amphibians and Reptiles. Natural Resource Management Center and Ministry of Natural Resources and University of the Philippines, Quezon City, Philippines.

Alcala, A. C., & Brown, W. C. 1998. Philippine Amphibians: an Illustrated Field Guide. Bookmark Press, Makati City, Philippines.

Alcala, E. L., Alcala, A. C., & Dolino, C. N. 2004. Amphibians and reptiles in tropical rainforest fragments on Negros Island, the Philippines. *Environmental Conservation* 31(3):254-261.

Alviola, P. A., Gonzales, J. C. T., Dans, A. T. L., Afuang, L. E., & Dimapilis, A. B. 1998. Herpetofauna of Puerto Galera, Mindoro Island. *Sylvatrop* 8(1&2):86-93.

Arsenio, J. A., Medecilo, M. P., Mercado, E., Salibay, & S.,Valera, F. 2011. Vegetation Analysis of Mt. Maculot, Cuenca, Batangas, Philippines. International Proceedings of Chemical, Biological and Environmental Engineering (IPCBEE). 252-256.

Baldera, J., Santos, M. M., Sopsop, G., & Abiog, R. 2004. 2003 Rapid biodiversity surveys in the Mantalingahan Range Forests. A poster presented at the 13th WCSP Annual Philippine Terrestrial Biodiversity Symposium, Assumption College, Antipolo, Antipolo City, Philippines.

Brigham, R. M. 1993. Riparian habitat and its importance for roosting and foraging by bats. Pp. 57-72. In: Morgan, K. H., & Lashmar, M. A. (eds.). Riparian habitat management and research. Proceedings of a workshop sponsored by Environment Canada and the British Columbia Forestry Continuing Studies Network. Kamloops, British Columbia.

Broad, G., & Oliveros, C. 2004. Biodiversity and conservation priority setting in the Babuyan Islands, Philippines. *Sylvatrop* 15(1&2):1-30.

Brown, R. M., Ferner, J. W., Sison, R. V., Gonzales, P. C., & Kennedy, R. S. 1996. Amphibians and reptiles of the Zambales Mountains of Luzon Island, Republic of the Philippines. *Herpetological Natural History* 4:1-22.

Brown, R. M., McGuire, J.A., Ferner, J.W., Icarangal, N., & Kennedy, R. S. 2000. Amphibians and reptiles of Luzon Island, II: preliminary report on the herpetofauna of Aurora Memorial National Park, Philippines. *Hamadryad* 25:175-195.

Brown, W. C., & Alcala A. C. 1986. Comparison of the herpetofaunal species richness on Negros and Cebu Islands, Philippines. *Silliman Journal* 33:74–86.

Brown, W. C., Alcala, A. C., & Diesmos, A. C. 1997a. A new species of the genus *Platymantis* (Amphibia: Ranidae) from Luzon Island, Philippines. *Proceedings of the Biological Society of Washington* 110:18–23.

Brown, W. C., Alcala, A. C., Diesmos, A. C., & Alcala, E. 1997b. Species of the *güntheri* group of *Platymantis* with descriptions of four new species. *Proceedings of the California Academy of Sciences* 50:1–20.

Brown, W. C., Brown, R. M., & Alcala, A. C. 1997c. Species of the *hazelae* group of *Platymantis* (Amphibia: Ranidae) from the Philippines, with descriptions of two new species. *Proceedings of the California Academy of Sciences* 49:405–421.

Bunnell, F. L., & Dupuis, L. A. 1993. Riparian habitats in British Columbia: their nature and role. Pp. 4-21. In: Morgan, K.H., Lashmar, M.A. (eds.). Riparian habitat management and research. Proceedings of a workshop sponsored by Environment Canada and the British Columbia Forestry Continuing Studies Network. Kamloops, British Columbia.

Causaren, R. M. 2009. Preliminary report on the anurans of Mts. Palay-Palay Mataas-na-Gulod Protected Landscape, Luzon Island, Philippines. *Philippine Journal of Systematic Biology* 3:40-56.

_____. 2012. Determinants of species diversity, abundance and habitat associations of the anuran fauna from forest fragments in Cavite, Luzon Island, Philippines. Manila, Philippines: De La Salle University: Unpublished PhD Dissertation.

Celis, M. O., Crisostomo, R. S., & Untivero, O. A. 1997. A survey of amphibian fauna in Mts. Palay-Palay/ Mataas na Gulod, Ternate, Cavite. Cavite, Philippines: De La Salle University-Dasmariñas: Unpublished Undergraduate Thesis.

Colwell, R. 2009. Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, USA. Available from: http://purl.oclc.org/estimates or http://viceroy.eeb.uconn.edu/estimates

Crump, M. 1982. Amphibian reproductive ecology on the community level Pp. 21-36 *In*: Herpetological Com-

munities. NJ Scott, Jr. (ed.). U.S. Fish and Wildlife Research Report 13.

Crump, M., & Scott, N. J. 1994. Visual encounter surveys. Pages 84–92 In: Heyer, W. R., Donnelly, M. A., McDiarmid, R. W., Hayek, L.A. C., & Foster, M. S. (eds.). *Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians*. Smithsonian Institution Press, Washington, D.C., USA.

Department of Environment and Natural Resources (DENR). 1992. Master Plan for Forest Development, Manila.

De Souza, A. M., & Eterovick, P. C. 2010. Environmental factors related to anuran assemblage composition, richness and distribution at four large rivers under varied impact levels in southeastern Brazil. *River Research and Applications* 27(8):1023–1036.

Diesmos, A. C. 1998. The Amphibian Faunas of Mt. Banahao, Mt. San Cristobal, and Mt. Maquiling, Luzon Island, Philippines. Laguna, Philippines: University of the Philippines at Los Baños College: Unpublished Master's Thesis.

_____. 1999. Frogs of Mt. Maquiling and Mt. Banahao. Rapid Color Guide #51 version 1.0 October 1999.

_____. 2008. Ecology and diversity of herpetofaunal communities in a fragmented lowland rainforest in the Philippines. Singapore: National University of Singapore: Unpublished PhD Dissertation.

Diesmos, A. C., Brown, R. M., & Alcala, A. C. 2002a. New species of narrow-mouthed frog (Amphibia: Anura; Microhylidae; genus *Kaloula*) from the mountains of southern Luzon and Polillo islands, Philippines. *Copeia*:1037–1051.

Diesmos, A. C., Brown, R. M., Alcala, A. C., Sison, R. V., Afuang, L. E., & Gee, G. V. A. 2002b. Amphibians and Reptiles. Pp. 26-44 *In*: Ong, P. S., Afuang, L. E., & Rosell-Ambal, R. G. (eds.). *Philippine Biodiversity Conservation Priorities: A Second Iteration of the National Biodiversity and Action Plan*. DENR-Protected Areas and Wildlife Bureau, Conservation International Philippines, Biodiversity Conservation Program-UP CIDS, and Foundation for the Philippine Environment, Quezon City, Philippines.

Diesmos, A. C., Brown, R.M., & Gee, G. V. A. 2003. Preliminary report on the amphibians and reptiles of Balbalasang-Balbalan Natural Park, Kalinga Province, Luzon Island, Philippines. *Sylvatrop* 13(1&2):63-80.

Diesmos, M. L. L., Diesmos, A. C., Vredenburg, V., & Brown, R. 2009. A country-wide survey for Chytrid fungus (*Batrachochytrium dendrobatidis*) in the Philippines. A paper presented at the 18th WCSP Annual Philippine Biodiversity Symposium held at the UP Baguio Auditorium.

Dixo, M., & Martins, M. 2008. Short communication: Are leaf-litter frogs and lizards affected by edge effects due to forest fragmentation in Brazilian Atlantic forest? *Journal of Tropical Ecology* 24:551–554.

Duya, M. R., Alviola, P. A., Duya, M. H., & Bueser, G. L. 2004. Filling in the gaps: The biodiversity of the Sierra Madre Mountains. A paper presented at the 13th WCSP Annual Philippine Terrestrial Biodiversity Symposium, Assumption College, Antipolo, Antipolo City, Philippines.

Environmental Science for Social Change. '2002 Forest Cover of the Philippines' [map]. 1:250,000. 2002 Forest Cover of the Philippines Series Number 2514. Available from: http://essc.org.ph/component/option,com_wrapper/Itemid,109/. Accessed March 2010.

Frost, D. R. 2011. Amphibian Species of the World: an Online Reference. Version 5.5 (31 January, 2011). Electronic Database accessible at http://research.amnh.org/vz/herpetology/ amphibia/ American Museum of Natural History, New York, USA.

Gaston, K. J. (ed.). 1996. Species richness: measure and measurement. Biodiversity. A Biology of Numbers and Difference, pp. 77–113. Blackwell Science, Oxford.

Gotelli, N. J., & Colwell, R. K. 2001. Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. *Ecology Letters* 4:379-391.

Green, D. 2007. Biological Processes in Riparian Areas – Habitat. Pp. 55-69. In: Zaimes, G. Understanding Arizona's Riparian Areas. Cooperative Extension, College of Agriculture and Life Sciences, The University of Arizona.

Guppy, C. 1993. Utilization of riparian habitats by terrestrial arthropods. Pp. 48. In: Morgan, K. H., & Lashmar, M. A. (eds.). Riparian habitat management and research. Proceedings of a workshop sponsored by Environment Canada and the British Columbia Forestry Continuing Studies Network. Kamloops, British Columbia.

Hampson, K. 2001. Amphibian distribution and abundance in the Pollillo Islands. Polillo Project: Amphibian Survey 2001.Harper, K. A., MacDonald, S. E., Burton, P., Chen, J., Brosofsky, K. D., Saunders, S., Euskirchen, E. S., Roberts, D., Jaiteh, M., Esseen, P. A. 2005. Edge influence on forest structure and composition in fragmented landscapes. *Conservation Biology* 19:768 –782.

Heatwole, H. 1982. A review of structuring in herpetofaunal assemblages. Pp 1-19 *In*: Herpetological Communities. Scott Jr., N. (ed.). U.S. Fish and Wildlife Res. Rept. 13.

Heyer, W. R., Donnelly, M. A., McDiarmid, R. W., Hayek, L. C., & Foster, M. S. 1994. Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. Smithsonian Institution Press. pp.41-104, 275-279.

Hortal, J., Borges, P. A. V., & Gaspar, C. 2006. Evaluating the performance of species richness estimators: sensitivity to sample grain size. *Journal of Animal Ecology* 75:274–287.

Inger, R. F., & Stuebing, R. B. 1997. A Field Guide to the Frogs of Borneo. Natural History Publications (Borneo) Sdn. Bhd. In association with Science and Technology Unit, Sabah. 205 pp.

International Union for Conservation of Nature (IUCN). The World Conservation Union. 2010. IUCN Red List of Threatened Species. Version 2010.4. <www.iucnredlist.org>. Downloaded 02 May 2011.

Kluber, M. R., Olson, D. H., & Puettmann, K. J. 2008. Amphibian distributions in riparian and upslope areas and their habitat associations on managed forest landscapes in the Oregon Coast Range. *Forest Ecology and Management* 256:529–535.

Lagat, R. D. 1999. Distribution patterns and observations on the influence of environmental factors on selected lizard species of Mts. Palay-Palay/-Mataas-na-Gulod National Park, Luzon Island, Philippines. Cavite, Philippines: De La Salle University-Dasmariñas: Unpublished Master's Thesis.

_____. 2009. A Taxonomic account of lizards along established trails in Mts. Palay-Palay/ Mataas-na-Gulod Protected Landscape, Luzon Island, Philippines. Philippine Journal of Systematic Biology 3:17-28.

_____. 2012. Determinants of species diversity and occupancy of lizard fauna in the remaining forest patches of Cavite, Luzon Island, Philippines. Manila, Philippines: De La Salle University: Unpublished PhD Dissertation.

Liu, D. S., Iverson, L. R., & Brown, S. 1993. Rates and patterns of deforestation in the Philippines: application of geographic information system analysis. *Forest Ecology and Management* 57:1-16.

Loehle, C., Wigley, T. B., Shipman, P. A., Fox, S. F., Rutzmoser, S., Thill, R. E., & Melchiors, M. A. 2005. Herpetofaunal species richness responses to forest landscape structure in Arkansas. *Forest Ecology and Management* 209:293–308.

Luyon, H. A.V., & Medecilo, M. P. 2006. An analysis of the dipterocarp vegetation of Mts. Mts. Palay-palay/ Mataas-na-Gulod National Park, Luzon Island, Philippines. *Sinag* 10(2):121-147.

Magurran, A. E. 1988. Ecological Diversity and Its Measurement. Princeton University Press, Princeton, NJ.

Mallari, N. A. D. 2009. Maximising the value of ecological and socio-economic data in support of conservation planning for key understorey bird species in Palawan, Philippines. Manchester, England: Manchester Metropolitan University: Unpublished PhD Dissertation.

Mallari, N. A. D., Tabaranza Jr., B. R., & Crosby, M. J. 2001. Key Conservation Sites in the Philippines: A Haribon Foundation and BirdLife International Directory of Important Bird Areas. Bookmark, Inc., Makati City, Philippines.

Paloma, M. C. S., & Panganiban, E. M. 1998. Herpetofauna found in Mts. Palay-palay/Mataas na Gulod, Ternate, Cavite. Cavite, Philippines: De La Salle University-Dasmariñas: Unpublished Undergraduate Thesis.

Peneyra, M. A. 2004. Diversity and ecology of frogs (Amphibia, Anura) along Bonton Stream, Irawan, Puerto Princesa City, Palawan, Philippines. A paper presented at the 13th WCSP Annual Philippine Terrestrial Biodiversity Symposium, Assumption College, Antipolo, Antipolo City, Philippines.

Pisani, G. R. 1973.A guide to preservation techniques for amphibians and reptiles. Society for the Study of Amphibians and Reptiles. Miscellaneous publications. *Herpetological Circular No.* 1:1-23.

Poulin, V. 1993. Importance of riparian habitat to fish. Pp. 22-30. In: Morgan, K. H., Lashmar, M.A. (eds.). Riparian habitat management and research. Proceedings of a workshop sponsored by Environment Canada and the British Columbia Forestry Continuing Studies Network. Kamloops, British Columbia.

Pussey, B. J., & Arthington, A. H. 2003. Importance of the riparian zone to the conservation and management of freshwater fish: a review. *Marine and Freshwater Research* 54:1-16.

Ross, C. A., & Gonzales, P. C. 1992. Amphibians and reptiles of Catanduanes Island, Philippines. National Museum Papers (Manila) 2:50-76.

Shannon, C. E. 1948. A mathematical theory of communication. *The Bell System Technical Journal* 27:379-423 and 623-656.

Skerratt, L. F., Berger, L., Speare, R., Cashins, S., McDonald, K. R., Phillott, A. D., Hines, H. B., & Kenyon, N. 2007. Spread of chytridiomycosis has caused the rapid global decline and extinction of frogs. *EcoHealth* 4:125–134.

Stigler, S. M. 1977. Do robust estimators work with real data? *Annals of Statistics* 5: 1055-1098.

Sørensen, T. 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species and its application to analyses of the vegetation on Danish commons. Biologiske Skrifter / Kongelige Danske Videnskabernes Selskab 5:1-34.

Swei, A., Rowley, J. J. L., Rödder, D., Diesmos, M. L. L., Diesmos, A. C., Briggs, C. J., Brown, R. M., Cao, T. T., Cheng, T. L., Chong, R. A., Han, B., Hero, J., Hoang, H. D., Kusrini, M. D., Le, D. T. T., McGuire, J. A., Meegaskumbura, M., Min, M., Mulcahy, D. G., Neang, T., Phimmachak, S., Rao, D., Reeder, N. M., Schoville, S. D., Sivongxay, N., Srei, N., Stöck, M., Stuart, B.L., Torres, L. S., Tran, D. T. A., Tunstall, T. S., Vieites, D., & Vredenburg, V. T. 2011a. Is Chytridiomycosis an Emerging Infectious Disease in Asia? *PLoS ONE* 6(8): e23179.

_____. 2011b. Prevalence and distribution of chytridiomycosis throughout Asia. *FrogLog* 98:33-34.

Ticsay, M. V., & Ledesma, M. M. 1999. Faunal inventory of Naujan Lake National Park and its adjacent watershed, Oriental Mindoro, Philippines. *Sylvatrop* 8(1&2):62-78.

Tumaneng-Diete, T., Ferguson, I. S., & MacLaren, D. 2005. Log export restrictions and trade policies in the Philippines: bane or blessing to sustainable forest management? *Forest Policy and Economics* 7:187-198.

Veith, M., Lötters, S., Andreone, F., & Rödel, M. O. 2004. Measuring and monitoring amphibian diversity in tropical forests. II. Estimating species richness from standardized transect censing. *Ecotropica* 10:85–99.

Wake, D. B., Vredenburg, V. T. 2008. Are we in the midst of the sixth mass extinction? A view from the world of amphibians. Proceedings of the National Academy of Sciences of the United States of America 105:11466-11473.

Weir, R. 1993. Use of riparian and riparian-associated habitats by fishers. Pp. 49-56. *In*: Morgan, K.H., Lashmar, M.A. (eds.). Riparian habitat management and research. Proceedings of a workshop sponsored by Environment Canada and the British Columbia Forestry Continuing Studies Network. Kamloops, British Columbia.

Zaimes, G. 2007. Defining Arizona's Riparian Areas and their Importance to the Landscape. Pp. 1-14. *In*: Zaimes, G (Ed.). Understanding Arizona's Riparian Areas. Cooperative Extension, College of Agriculture and Life Sciences, The University of Arizona.